4.0 SENSITIVITY ANALYSIS

While the preferred option was found to result in the most positive economic indicator within its competing class, it should be noted that none resulted in a strong case for project implementation in the near future. With benefit-cost ratios less than 1.0 and negative net present values, to society it is likely that each of these proposed improvement options would face difficult project justification circumstances in typical government investment processes. Keeping in mind the difficulty in predicting key variables in the benefit-cost equation, such as costs or traffic growth, it is possible that different assumptions could alter the end result. In order to ensure that the conclusions reached are sound and resilient, it is common practice for both BCMoT and WSDOT benefit cost methodologies to conduct sensitivity tests of selected variables.

Four key variables in the benefit cost equation were tested as follows:

- Vehicle Operating Costs
- Traffic Growth Rate
- Discount Rate
- Cost Estimate

4.1 Northern Sub-Area

4.1.1 Vehicle Operating Costs

During the course of this study stakeholders indicated that vehicle operating costs are likely much higher than provincial or state-wide averages due to the topography and weather conditions. To respond to this likelihood, the benefit cost calculations were repeated using double and triple the base values specified by BCMoT and WSDOT, while keeping all other variables constant. The results are demonstrated in **Table 30**.

Table 30: Vehicle Operating Cost Sensitivity Tests

Account	1 x Veh. Costs		2 x Veh. Costs		3 x Veh. Costs	
	$ CAD	$ USD	$ CAD	$ USD	$ CAD	$ USD
Total Benefits	16.6 M	10.1 M	25.5 M	15.9 M	34.4 M	21.6 M
Total Costs	38.1 M	31.2 M	38.1 M	31.2 M	38.1 M	31.2 M
B/C ratio	0.44	0.32	0.67	0.51	0.91	0.69
NPV	(21.5 M)	(21.1 M)	(12.5 M)	(15.3 M)	(3.6 M)	(9.6 M)
NPV/Cost ratio	-0.56	-0.68	-0.33	-0.49	-0.09	-0.31

Neither doubling nor tripling vehicle operating cost rates results in a benefit cost ratio greater than 1.0. It can be concluded that even if local vehicle operating costs are significantly higher than provincial or state-wide averages, the difficult project justification circumstances would remain.

4.1.2 Traffic Growth Rate

Since the customer service account benefits (mobility and safety) are directly influenced by the amount of existing and forecasted traffic considered, the analysis results are often quite sensitive to the background traffic growth rate utilized in the analysis. In this test, the analysis was repeated using increased traffic growth rates until a benefit cost ratio greater than 1.0 was achieved for both BCMoT and WSDOT unit rates. The results of this analysis are summarized below in **Table 31**.

Table 31: Traffic Growth Rate Sensitivity Tests

Account	2%		9%		11.5%	
	$ CAD	$ USD	$ CAD	$ USD	$ CAD	$ USD
Total Benefits	16.6 M	10.1 M	38.5 M	23.6 M	53.2 M	32.7 M
Total Costs	38.1 M	31.2 M	38.1 M	31.2 M	38.1 M	31.2 M
B/C ratio	0.44	0.32	1.01	0.76	1.40	1.05
NPV	(21.5 M)	(21.1 M)	0.4 M	(7.6 M)	15.1 M	1.5 M
NPV/Cost ratio	-0.56	-0.68	0.01	-0.24	-0.45	-0.59

Traffic growth rates of 9% and 11.5% per year over 20 years would be required in order to achieve benefit cost ratios greater than 1.0. As these traffic growth rates would be unrealistically high under any circumstances, the conclusion can be drawn that even the most optimistic forecasts of background traffic growth for the region would not improve the overall viability of the project in the short term.

4.1.3 Discount Rate

Both the benefit cost methodologies used by BCMoT and WSDOT uses a "constant dollar" approach to estimate the value of future benefits and costs by applying a discount rate to costs over the life span of the project (20 years). This approach allows the value of benefits and other annual costs, such as maintenance, over the 20 year lifespan of the project to be compared in today's dollars to the initial capital costs of the project. A 6% discount rate was used as prescribed by the BCMoT. However, since WSDOT uses a default discount rate of 4% in its methodology the analysis was repeated

using both a 4% and 5% discount rate for the purposes of comparison. The results of this test are shown in the following table.

Table 32: Discount Rate Sensitivity Tests

Account	6%		5%		4%	
	$ CAD	$ USD	$ CAD	$ USD	$ CAD	$ USD
Total Benefits	16.6 M	10.1 M	18.5 M	11.3 M	20.8 M	12.7 M
Total Costs	38.1 M	31.2 M	38.1 M	31.2 M	38.1 M	31.2 M
B/C ratio	0.44	0.32	0.49	0.36	0.55	0.41
NPV	(21.5 M)	(21.1 M)	(19.5 M)	(19.9 M)	(17.3 M)	(18.5 M)
NPV/Cost ratio	-0.56	-0.68	-0.51	-0.64	-0.45	-0.59

It can be concluded that using lower discount rates do not significantly alter the conclusions of this analysis.

4.1.4 Cost Estimate

At this level of project planning it is difficult to accurately estimate the final costs, given the high number of unknown factors and the limitations of the base mapping and the stage of design. While a contingency factor of 40% was added to the estimates to account for any unforeseen costs, it is likely that a more detailed cost estimate would produce a different result and therefore different economic indicators. For this reason it is often useful to repeat the benefit cost analysis using both higher and lower costs estimates. For this test, cost estimates of 50% and 150% of the original value were used. A summary of the results is shown below in **Table 33**.

Table 33: Cost Estimate Sensitivity Tests

Account	100%		50%		150%	
	$ CAD	$ USD	$ CAD	$ USD	$ CAD	$ USD
Total Benefits	16.6 M	10.1 M	16.6 M	10.1 M	16.6 M	10.1 M
Total Costs	38.1 M	31.2 M	19.6 M	16.1 M	56.5 M	46.3 M
B/C ratio	0.44	0.32	0.85	0.63	0.29	0.22
NPV	(21.5 M)	(21.1 M)	(3.0 M)	(5.9 M)	(39.9 M)	(36.2 M)
NPV/Cost ratio	-0.56	-0.68	-0.15	-0.37	-0.71	-0.78

Even assuming a 50% reduction in the estimated project cost does not yield a benefit cost ratio greater that 1.0. On the other hand a 50% increase in the initial cost estimate only further reduces the economic indicators of the project, as would be expected.

4.2 Sensitivity Analysis – Southern Sub-Area

In comparison to the northern sub-area, the analysis of the favoured option in the southern area resulted in relatively stronger economic indicators. While still somewhat less than the preferred b/c ratio of 1.0 or greater, the initial analysis resulted in a B/C ratio of 0.85. As in the northern sub-area a sensitivity analysis of the noted assumptions was undertaken in order to evaluate their effects on the end result.

4.2.1 Vehicle Operating Costs

Benefit Cost analysis was repeated using vehicle operating costs double and triple the default state-wide averages. As is shown in **Table 34**, increased vehicle operating cost improve the economic indicators for this improvement option.

Table 34: Vehicle Operating Costs Sensitivity Tests

Account	1 x Veh. Costs	2 x Veh. Costs	3 x Veh. Costs
	$ USD	$ USD	$ USD
Total Benefits	29.0 M	47.7 M	66.4 M
Total Costs	34.0 M	34.0 M	34.0 M
B/C ratio	0.85	1.40	1.95
NPV	(5.0 M)	13.7 M	32.3 M
NPV/Cost ratio	-0.15	0.40	0.95

4.2.2 Traffic Growth Rate

Increased traffic growth rates were also tested, as in northern sub-area. First as shown in **Table 35**, a growth rate of 3.5% per year was found to be required to achieve a B/C ratio greater than 1.0 (over the 20 year life of the project). While a 10% background traffic growth rate (approximately what was required in the northern sub-area), resulted in a very solid B/C ratio of 2.27.

Table 35: Traffic Growth Rate Sensitivity Tests

Account	2%	3.5 %	10%
	$ USD	$ USD	$ USD
Total Benefits	29.0 M	34.5 M	77.3 M
Total Costs	34.0 M	34.0 M	34.0 M
B/C ratio	0.85	1.01	2.27
NPV	(5.0 M)	0.5 M	43.3 M
NPV/Cost ratio	-0.15	0.01	1.27

4.2.3 Discount Rate

As described earlier the default discount rate for WSDOT is 4%, while 6% was used for the initial analysis. As in the northern sub-area, discount rates of 5% and 4% were tested in order to compare their effect on the final results. As summarized in **Table 36**, using lower discount rates results in improved economic indicators and using a discount rate of 4% results in a B/C ratio greater than 1.0.

Table 36: Discount Rate Sensitivity Tests

Account	6%	5 %	4%
	$ USD	$ USD	$ USD
Total Benefits	29.0 M	32.0 M	36.5 M
Total Costs	34.0 M	34.0 M	34.0 M
B/C ratio	0.85	0.95	1.07
NPV	(5.0 M)	(1.6 M)	2.4 M
NPV/Cost ratio	-0.15	-0.05	0.07

4.2.4 Cost Estimate

At this high level of highway planning, it can be quite difficult to accurately estimate proposed construction costs. Therefore it is often useful to consider both higher and lower cost estimates, in order to evaluate the sensitivity of the analysis to this variable. In this case, cost estimates of 50% and 150% of the original value were considered. A summary of the results is shown in **Table 37**. As expected, a reduced cost estimate improves the economic indicators for this option and in fact results in a B/C ratio of 1.71. On the other hand, an increased cost estimate lowers the resulting economic indicators.

Table 37: Cost Estimate Sensitivity Tests

Account	100%	50%	150%
	$ USD	$ USD	$ USD
Total Benefits	29.0 M	29.0 M	29.0 M
Total Costs	34.0 M	17.0 M	51.0 M
B/C ratio	0.85	1.71	0.57
NPV	(5.0 M)	12.0 M	(22.0 M)
NPV/Cost ratio	-0.15	0.71	-0.43